US006002929A

United States Patent [19]

Bishop, Jr. et al.

[11] Patent Number: 6,002,929

[45] Date of Patent: Dec. 14, 1999

[54] **EXCHANGE WHICH EXTENDS SIM BASED AUTHENTICATION AND METHOD THEREFOR**

[75] Inventors: **James William Bishop, Jr.**, Chandler; **Steve Magee**, Scottsdale, both of Ariz.; **Nathan Miller**, Santa Rosa, Calif.

[73] Assignee: **Mototrola, Inc.**, Schaumburg, Ill.

[21] Appl. No.: **08/939,890**

[22] Filed: **Sep. 29, 1997**

[51] **Int. Cl.**[6] **H04M 11/00**; H04Q 7/32

[52] **U.S. Cl.** **455/431**; 455/411; 455/558; 455/410

[58] **Field of Search** 455/411, 410, 455/408, 407, 425, 431, 558, 551

[56] **References Cited**

U.S. PATENT DOCUMENTS

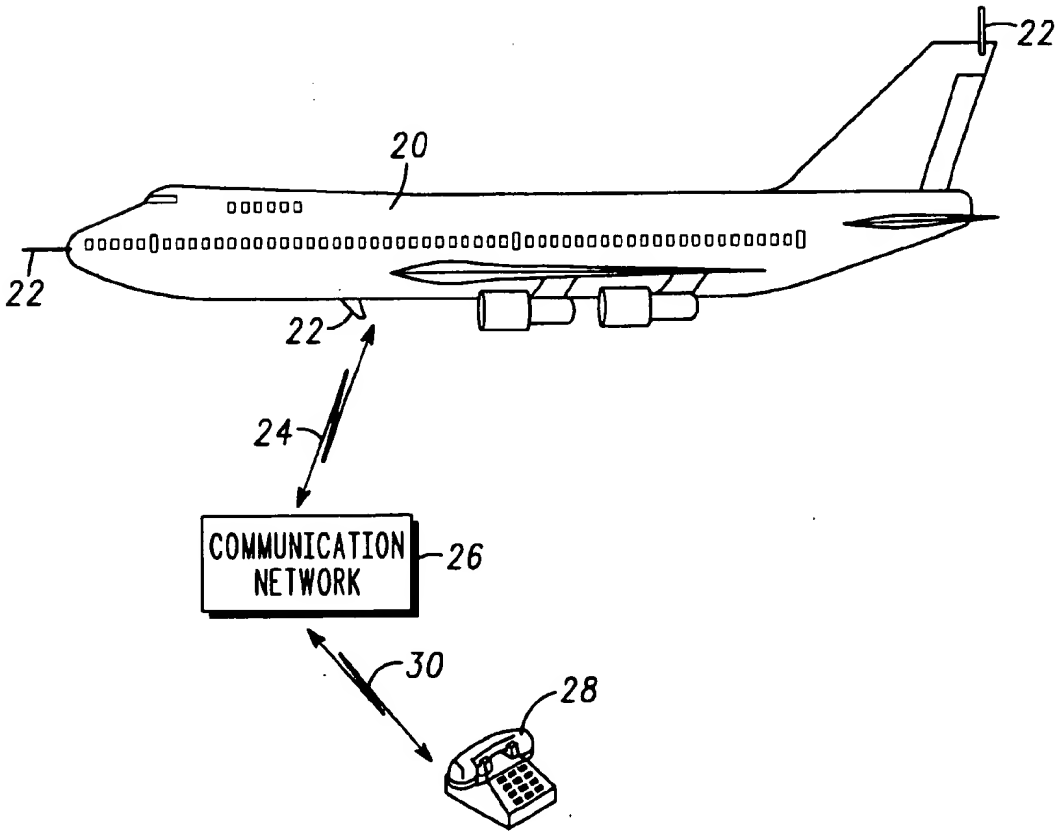
4,811,377	3/1989	Krolopp et al.	379/62
5,438,610	8/1995	Bhagat et al.	379/58
5,497,411	3/1996	Pellerin	379/59
5,519,761	5/1996	Gilhousen	379/59
5,765,105	6/1998	Kuriki	455/410
5,819,176	10/1998	Rast	455/422
5,875,404	2/1999	Messiet	455/558

Primary Examiner—Dwayne D. Bost
Assistant Examiner—Joy Redmon
Attorney, Agent, or Firm—Harold C. McGurk; Timonthy J. Lorenz

[57] **ABSTRACT**

An on-board aircraft telecommunication exchange (**32**) provides communication and authentication services for M subscriber identity modules (SIMs) using N transceivers (**36**), where M can be greater than N. Associations between SIMs (**56**) and transceivers (**36**) are established when needed. Accordingly, a pool of transceivers **36** is provided to serve the collective needs of many subscribers. A SIM-based authentication process is performed (**100**) using a subscriber's original SIM (**56**). That authentication can be extended to a temporary SIM (**106**) that is substituted for the original SIM throughout the remainder of a flight. Alternatively, the original SIMs (**56**) may be locked in place and relinquished when a subscriber provides an appropriate PIN.

19 Claims, 6 Drawing Sheets



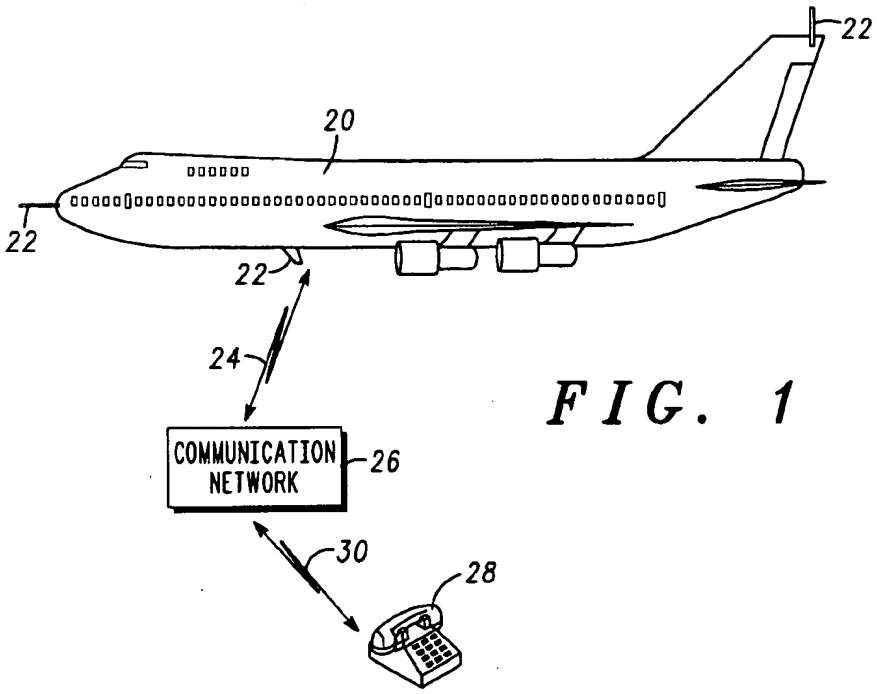

22
20
22
22
24
COMMUNICATION NETWORK
26
30
28

FIG. 1

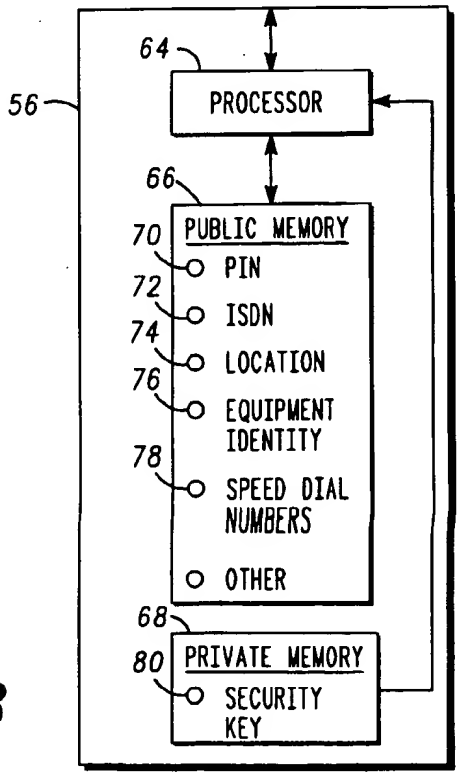
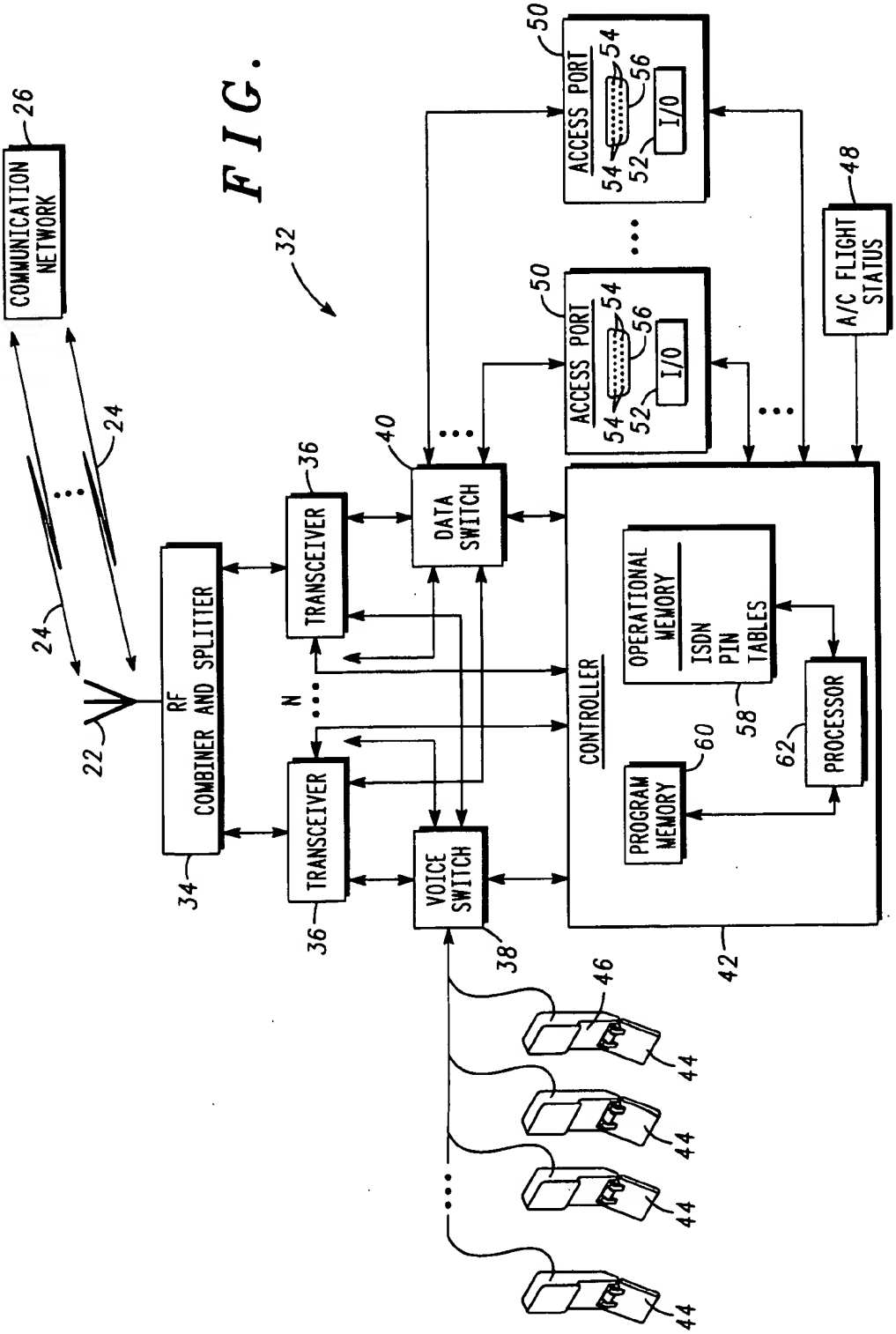

64
56
PROCESSOR
66
PUBLIC MEMORY
70
PIN
72
ISDN
74
LOCATION
76
EQUIPMENT IDENTITY
78
SPEED DIAL NUMBERS
OTHER
68
PRIVATE MEMORY
80
SECURITY KEY

FIG. 3

FIG. 2


32
COMMUNICATION NETWORK
26
24
24
22
RF COMBINER AND SPLITTER
34
TRANSCEIVER
36
TRANSCEIVER
36
N
DATA SWITCH
40
VOICE SWITCH
38
ACCESS PORT
50
54
56
I/O
52
ACCESS PORT
50
54
56
I/O
52
A/C FLIGHT STATUS
48
CONTROLLER
42
OPERATIONAL MEMORY
ISDN PIN TABLES
58
PROCESSOR
62
PROGRAM MEMORY
60
46
44
44
44
44

EXEMPLARY CALL ASSOCIATION TABLE

81

82 84 70 72 83

SIM No.	SEAT BACK HANDSET No.	PIN	ISDN	TRANSCEIVER No.
1	22-B	5821	WW-XXX-YYY-ZZZZ	2
2	—	—	—	—
3	—	—	—	—
4	—	—	—	—
5	—	—	—	—
6	—	—	—	—
7	—	—	—	—
8	—	—	—	—
M	—	—	—	—

FIG. 4

85

AVAILABILITY LIST OF TRANSCEIVERS	
1	AVAILABLE
2	NOT AVAILABLE
3	AVAILABLE
4	RESERVED
5	AVAILABLE
⋮	↓
N	AVAILABLE

83

FIG. 5

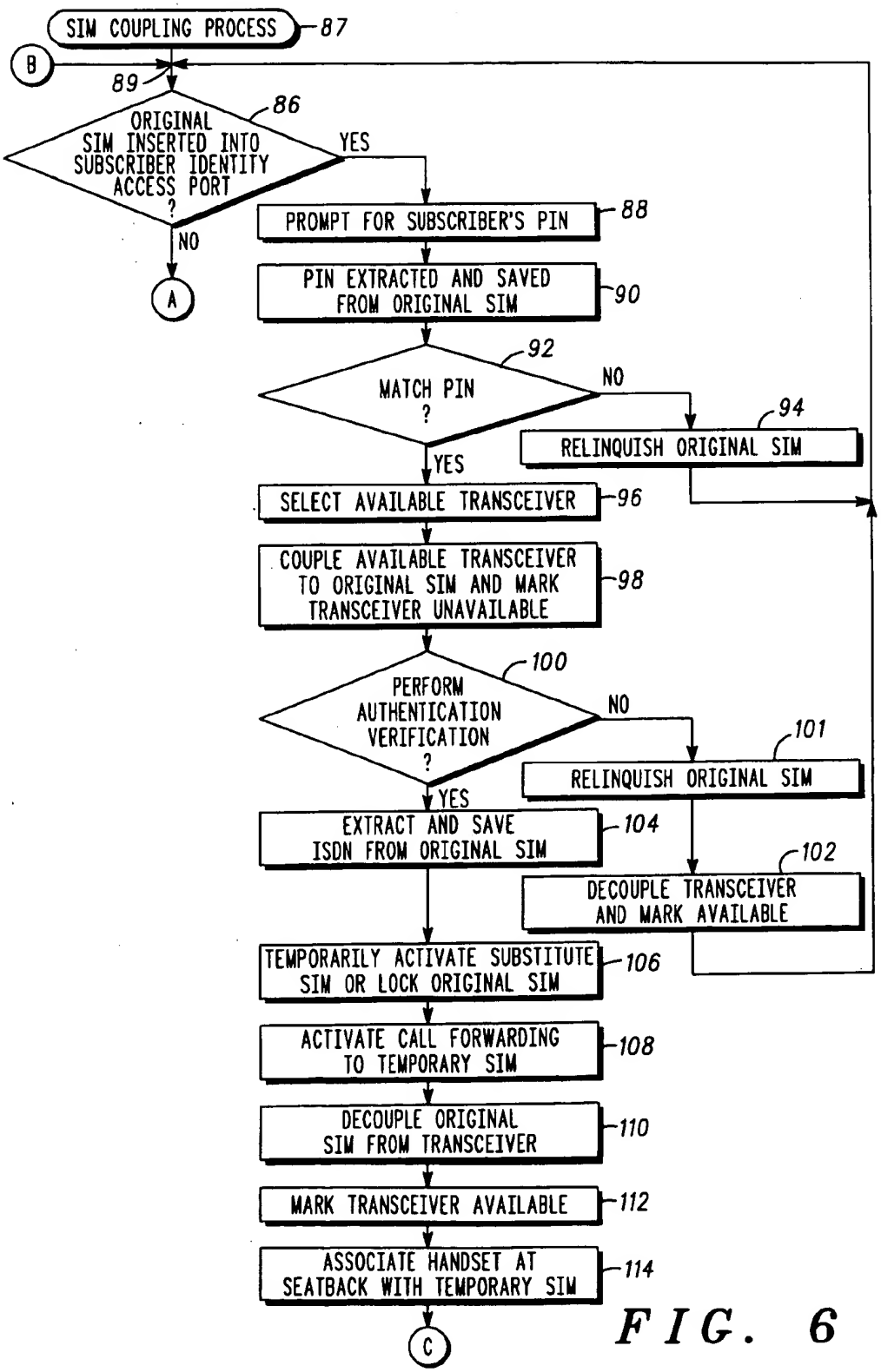
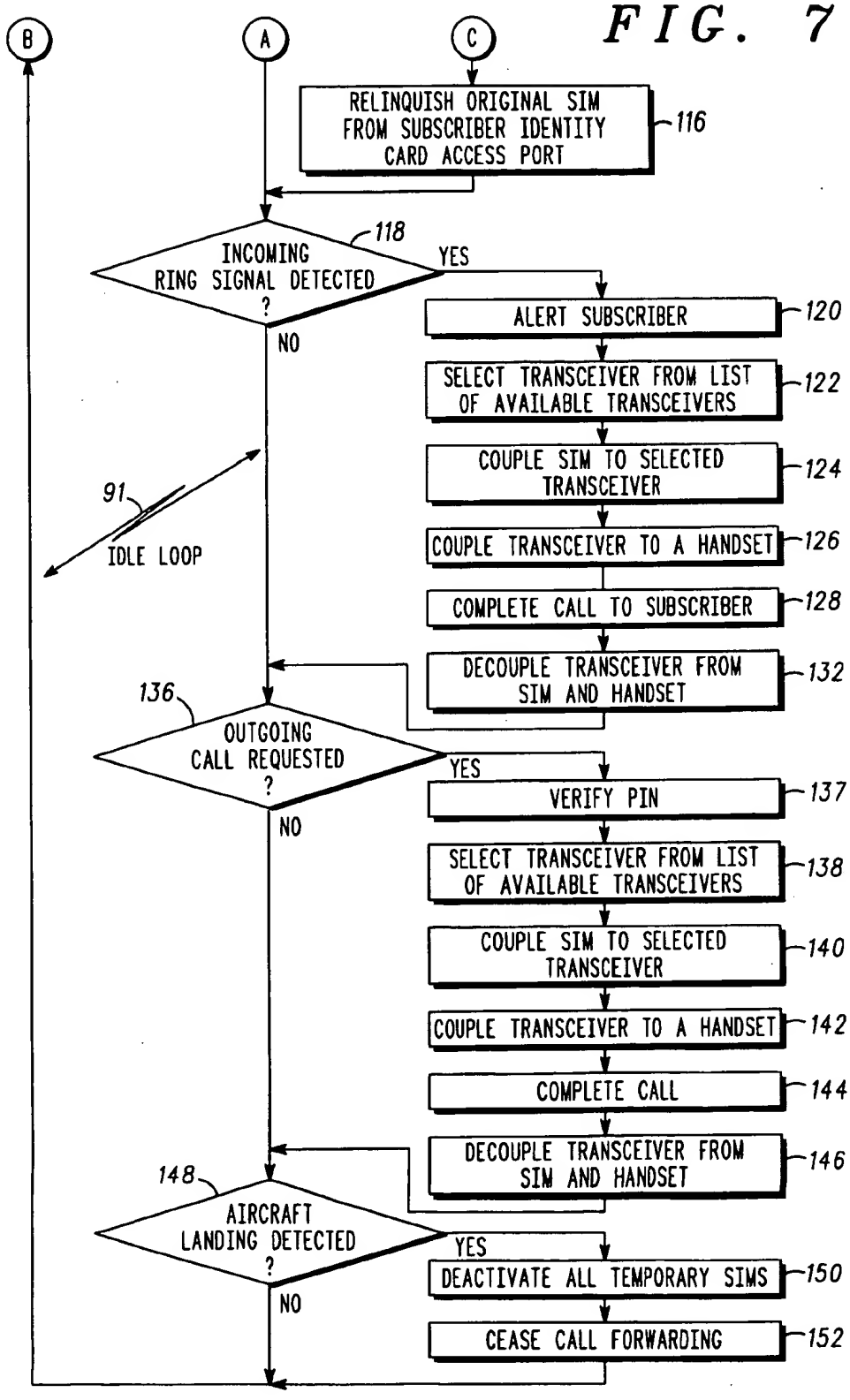

SIM COUPLING PROCESS
87
B
89
ORIGINAL SIM INSERTED INTO SUBSCRIBER IDENTITY ACCESS PORT ?
86
YES
NO
A
PROMPT FOR SUBSCRIBER'S PIN
88
PIN EXTRACTED AND SAVED FROM ORIGINAL SIM
90
MATCH PIN ?
92
NO
YES
RELINQUISH ORIGINAL SIM
94
SELECT AVAILABLE TRANSCEIVER
96
COUPLE AVAILABLE TRANSCEIVER TO ORIGINAL SIM AND MARK TRANSCEIVER UNAVAILABLE
98
PERFORM AUTHENTICATION VERIFICATION ?
100
NO
YES
RELINQUISH ORIGINAL SIM
101
EXTRACT AND SAVE ISDN FROM ORIGINAL SIM
104
DECOUPLE TRANSCEIVER AND MARK AVAILABLE
102
TEMPORARILY ACTIVATE SUBSTITUTE SIM OR LOCK ORIGINAL SIM
106
ACTIVATE CALL FORWARDING TO TEMPORARY SIM
108
DECOUPLE ORIGINAL SIM FROM TRANSCEIVER
110
MARK TRANSCEIVER AVAILABLE
112
ASSOCIATE HANDSET AT SEATBACK WITH TEMPORARY SIM
114
C

FIG. 6

FIG. 7


B
A
C
RELINQUISH ORIGINAL SIM FROM SUBSCRIBER IDENTITY CARD ACCESS PORT
116
118
INCOMING RING SIGNAL DETECTED ?
YES
NO
ALERT SUBSCRIBER
120
SELECT TRANSCEIVER FROM LIST OF AVAILABLE TRANSCEIVERS
122
COUPLE SIM TO SELECTED TRANSCEIVER
124
COUPLE TRANSCEIVER TO A HANDSET
126
COMPLETE CALL TO SUBSCRIBER
128
DECOUPLE TRANSCEIVER FROM SIM AND HANDSET
132
91
IDLE LOOP
136
OUTGOING CALL REQUESTED ?
YES
NO
VERIFY PIN
137
SELECT TRANSCEIVER FROM LIST OF AVAILABLE TRANSCEIVERS
138
COUPLE SIM TO SELECTED TRANSCEIVER
140
COUPLE TRANSCEIVER TO A HANDSET
142
COMPLETE CALL
144
DECOUPLE TRANSCEIVER FROM SIM AND HANDSET
146
148
AIRCRAFT LANDING DETECTED ?
YES
NO
DEACTIVATE ALL TEMPORARY SIMS
150
CEASE CALL FORWARDING
152

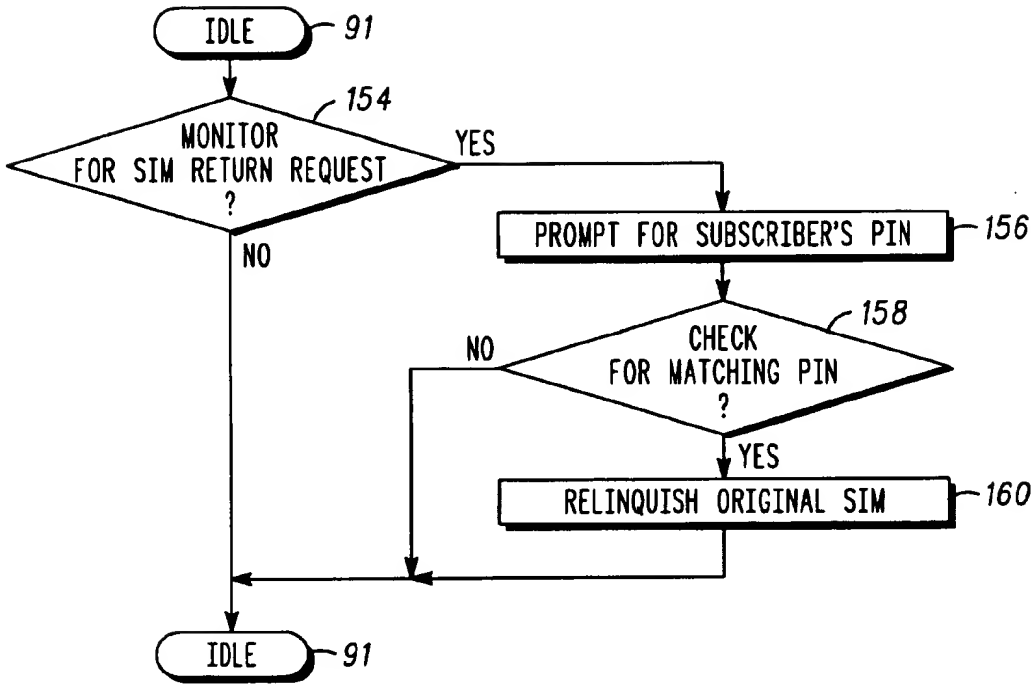

IDLE
91
154
MONITOR FOR SIM RETURN REQUEST ?
YES
NO
PROMPT FOR SUBSCRIBER'S PIN
156
158
CHECK FOR MATCHING PIN ?
NO
YES
RELINQUISH ORIGINAL SIM
160
IDLE
91

FIG. 8

EXCHANGE WHICH EXTENDS SIM BASED AUTHENTICATION AND METHOD THEREFOR

FIELD OF THE INVENTION

The present invention relates generally to the field of communication systems. More specifically, the present invention relates to communication systems that use subscriber identity modules (SIMs) to establish authentication.

BACKGROUND OF THE INVENTION

Modem cellular communication systems, such as GSM, the IRIDIUM® system and others, use subscriber identity module (SIM) cards to personalize radio units into which the SIM cards are installed. The personality given to a radio unit by a SIM card makes that radio unit serve the needs of the subscriber who owns the SIM card. Conventional SIM cards are smart cards which include subscriber-specific data and a processing capability. The data may define an international subscriber directory number (ISDN) or phone number, a subscriber's memorized speed dialing numbers, the identity of the subscriber, specific radio unit features to which the subscriber has subscribed, and a cryptographic security key.

Cellular communication systems require SIM cards in order to deliver communication services. For example, radio units are informed of incoming or terminating calls by ring alert or paging radio signals that convey ISDNs or TMSIs (temporary mobile subscriber identities). The presence and use of a SIM card is conventionally required in a particular radio unit so the radio unit will know which ISDN represents an incoming call to that particular radio unit.

The SIM card is also conventionally required as an integral part of system security. An authentication process is performed during registration and prior to servicing incoming and outgoing calls. Only if the authentication process is successful will the registration or call be allowed to take place. Typically, the system initiates the authentication process by issuing a random number to the SIM card being tested for authenticity. The processor on the SIM card then uses this random number, its internal cryptographic security key, and an encryption process performed by the SIM card to generate a response. The SIM response is sent back to the cellular system where it is tested for validity. If the cellular system determines that the SIM response is correct, the SIM card is declared valid.

To maintain system security, the SIM card is constructed so that its cryptographic security key cannot be read from or otherwise divulged by the SIM card. Because of this, a SIM card cannot be easily duplicated. Thus, the SIM card allows the system to provide authentication services in addition to communication services. The authentication services reduce the theft of communication services by unauthorized persons, allowing legitimate subscribers to enjoy reduced costs and better service quality as a result. The SIM card is a valuable item because it provides the key which unlocks communication services for which the subscriber will be billed. However, if the SIM card becomes lost or stolen, it may be fraudulently used to steal communication services using almost any radio unit.

As a consequence of the integration of SIM cards into the operation of cellular systems, a one-to-one correspondence between a SIM card and a radio unit conventionally results. This is because the SIM card is conventionally required to register and to make incoming and outgoing calls, and a radio unit can do very little without the SIM card being present.

Unfortunately, this one-to-one correspondence poses a problem for certain applications, such as public phone exchanges. One such application is a public phone exchange located in an aircraft. In an aircraft a subscriber's cellular phone may be unusable because the aircraft body may severely attenuate radio signals. A public exchange may be usable because an antenna for such an exchange may be located outside the aircraft body. Moreover, it would be desirable for a subscriber to use his or her SIM card with the public exchange so that billing records are kept straight and so that incoming calls may be directed to the user's ISDN. However, the one-to-one correspondence between SIM cards and transceivers would require a radio unit or transceiver for each subscriber wishing to take advantage of such a public phone exchange. Moreover, a public exchange which uses subscriber-provided SIM cards risks weakening security for the system and its subscribers because the SIM cards would be used in a public rather than private phone.

Accordingly, a need exists for a public phone exchange and method which extends the authentication services provided by the use of SIM cards without significantly weakening security and without requiring the inefficiency of a one-to-one correspondence between SIM cards and transceivers.

BRIEF DESCRIPTION OF THE DRAWINGS

FIG. 1 shows a diagram of an exemplary aircraft and a radio communication system in which the present invention may be practiced;

FIG. 2 shows a block diagram of an exemplary multi-channel subscriber exchange and a communication network in accordance with a preferred embodiment of the present invention;

FIG. 3 shows a block diagram of an exemplary original SIM in accordance with a preferred embodiment of the present invention;

FIG. 4 shows an exemplary call association table in accordance with a preferred embodiment of the present invention;

FIG. 5 shows an exemplary availability list of transceivers in accordance with a preferred embodiment of the present invention;

FIG. 6 shows a first part of a flowchart for an exemplary SIM coupling process in accordance with a preferred embodiment of the present invention;

FIG. 7 shows a second part of a flowchart for the exemplary SIM coupling process in accordance with a preferred embodiment of the present invention; and

FIG. 8 shows a flowchart of an exemplary SIM relinquishing process in accordance with a preferred embodiment of the present invention.

DETAILED DESCRIPTION OF THE DRAWINGS

FIG. 1 shows a diagram of an exemplary aircraft and a radio communication system that may be used to practice the present invention. Aircraft **20** is shown with several radio communication antennas **22** of various shapes and at various external locations on the aircraft. Radio antennas **22** are used to receive and/or transmit radio signals or radio channels **24** between aircraft **20** and communication network **26**. In a preferred embodiment, communication network **26** is a cellular communication system, such as GSM for example. Communication network **26** is shown linked to phone **28**, which represents any one or all of a wide variety of conventional telephonic devices, such as public, private and

mobile phones or other telecommunication equipment. Phone **28** is linked to communication network **26** through communication channels **30**. Communication channels **30** include radio channels, terrestrial phone lines, and/or any combination thereof.

FIG. **2** shows a block diagram of an exemplary multi-channel subscriber exchange **32** coupled to communication network **26** which provides communication and authentication services for subscribers. Exchange **32** is located on aircraft **20** (FIG. **1**), and these services are provided to subscribers onboard aircraft **20**. Multiple radio channels **24** carry audio and data received and/or transmitted by aircraft antennas **22**. RF combiner/splitter **34** couples to at least one antenna **22** and processes radio channels **24** by combining outgoing radio channels for transmission and splitting incoming radio channels for reception. A quantity N, where N is an integer number, of transceivers **36** couple to combiner/splitter **34**. Transceivers **36** are linked to voice switch **38**, data switch **40**, and controller **42**. Voice switch **38** carries voice and data to and from any number of handsets **44**. Each handset **44** is associated with I/O device **46** that may include a keypad, a visual display and an audible alert system. In the preferred embodiment, handsets **44** are located on passenger seat backs in aircraft **20**. I/O device **46** functions as a subscriber or user interface so that the subscriber can supply information to and receive information from controller **42** and communication network **26**. I/O device **46** can audibly alert the subscriber to an incoming call, and display a prompt for and accept entry of the subscriber's PIN. Voice switch **38** and handsets **44** are included in conventional aircraft telecommunication networks found on most modern commercial aircraft and are not discussed in detail herein.

Data switch **40** carries digital data to and from subscriber identity access ports **50**. Each access port **50** or group of access ports **50** has I/O device **52**, such as a keypad and/or display, that functions as a subscriber interface. Access ports **50** are positioned at different locations in aircraft **20** for different embodiments. To some degree, the location of access ports **50** determines how controller **42** associates handsets **44** with original SIMs **56**. This association of handsets **44** and original SIMs **56** is shown in FIG. **4** and discussed in greater detail below. Each access port **50** may also have card locking mechanism **54** configured to hold a smart card or an original SIM **56**, discussed below.

FIG. **3** shows an exemplary block diagram of original SIM **56**. Original SIM **56** is a SIM card containing processor **64** coupled to public memory **66** and private memory **68**. Public memory **66** allows external read and write access for storing such items as a subscriber's personal identification number (PIN) **70**, a subscriber's international subscriber directory number (ISDN) **72**, a subscriber's location **74**, an equipment identity code **76**, a list of subscriber speed dial numbers **78**, and other subscriber specific information. PIN **70** is a subscriber unique numeric code that is used by exchange **32** to identify individual subscribers in a manner discussed in more detail below. Moreover, each subscriber has a unique phone number or ISDN **72** that is stored in public memory **66**. Whenever reference is made to an ISDN, it also refers to an identity alias, such as temporary mobile subscriber identity or TMSI, for example. Subscriber location **74** stores a geographic location of original SIM **56** that is determined and updated by communication network **26**. Equipment identity **76** stores a code that indicates the type of equipment with which original SIM **56** was last used.

Unlike public memory **66**, private memory **68** has a cryptographic security key **80** that cannot be overwritten or read externally from original SIM **56** but is only readable by processor **64**. Processor **64** uses an internal encryption process, security key **80** and a random number supplied by communication network **26** to perform a subscriber authentication process.

A SIM registration process occurs from time to time so that communication network **26** can learn the location of original SIM **56** and the radio equipment with which it is associated. The subscriber authentication process occurs as a part of this registration process. In addition, the registration process, including its embedded authentication process, takes place each time an incoming or outgoing call is set up. Accordingly, radio equipment, such as transceivers **36** (FIG. **2**), are coupled to SIMs in order to provide communication and authentication services.

Original SIM **56** is distinguished from a temporary SIM for the purposes of the present invention. Original SIM **56** is owned by or otherwise in the possession of a subscriber to communication network **26** and identifies the party (i.e. the subscriber) that will be billed for services performed for that original SIM. This subscriber may, for example, be a passenger on aircraft **20** (FIG. **1**). Unlike original SIM **56**, the temporary SIM may exist in software form only within exchange **32** and is temporarily associated with a specified original SIM **56**. Such an association is discussed in more detail below. The temporary SIM is possessed by the subscriber or passenger, although it is physically possessed by exchange **32**. Moreover, the temporary SIM may, but need not, include all the features of original SIM **56**. For example, the temporary SIM includes only ISDN **72** in one embodiment of the present invention and is stored in controller **42** (FIG. **2**).

Referring back to FIG. **2**, controller **42** includes program memory **60** and operational memory **58** coupled to processor **62**. Operational memory **58** stores temporary information such as PINs **70**, ISDNs **72** and various operating tables that are over-written or erased during the operation of exchange **32** during a flight and upon aircraft landing. An aircraft flight status indicator **48** of aircraft **20** is input to controller **42**. Flight status is obtained from an aircraft avionics system. Flight status indicator **48** informs controller **42** whether aircraft **20** is in flight or has landed.

Program memory **60** contains more permanent information, such as computer software programs that select, associate, and couple transceivers **36** and access ports **50** to handsets **44**. Unlike operational memory **58**, information stored in program memory **60** is retained after flight termination. Processor **62** uses operational memory **58** and program memory **60** while performing functional processing required by subscriber exchange **32**.

Subscriber exchange **32** accesses original SIMs **56** through access ports **50**. Locking mechanism **54** is depicted in FIG. **2** with four compression clips that may be electrically activated to hold or lock original SIM **56** in access port **50**. Those skilled in the art will realize that any of a variety of credit card type locking devices could be used as well. In one embodiment an integer quantity M of original SIMs **56** can be accessed through access ports **50**. The quantity M is typically larger than the quantity N of transceivers **36**. I/O device **52** is a user interface with communication network **26** and subscriber exchange **32**, and which allows the subscriber to enter a PIN or other such access code as required.

Each of subscriber identity access port **50**, voice switch **38** and data switch **40** couples to controller **42** and is controlled by controller **42**. Thus, controller **42** makes numerous couplings and associations between access ports **50**, original

SIMs **56**, temporary SIMs, transceivers **36** and handsets **44**, as described in more detail below.

FIG. **4** shows an exemplary call association table **81** that is stored in operational memory **58** of controller **42** (FIG. **2**). Table **81** is arranged to include a SIM number **82** in association with seat back handset number **84**, corresponding to handset **44** (FIG. **2**), PIN **70**, ISDN **72**, and transceiver number **83** corresponding to transceiver **36** (FIG. **2**). SIM no. **82** is an index number that corresponds to a specific SIM. The specific SIM can be one of many original SIMs **56** inserted into access ports **50** (FIG. **2**) or one of many temporary SIMs stored in program memory **60** (FIG. **2**) or otherwise possessed by exchange **32**. The coupling of transceivers **36** (FIG. **2**) with seat back handset numbers **84** is tracked through the use of transceiver no. **82** in a manner discussed below.

Controller **42** (FIG. **2**) assigns SIM no. **82** to the temporary SIMs and original SIMs **56** to track the association of each SIM with seat back handset no. **84**. The association between SIM no. **82** and seat back handset no. **84** enables controller **42** to complete incoming and outgoing calls to individual subscribers after controller **42** couples selected transceiver **36** to an appropriate original or temporary SIM that is associated with seat back handset no. **84**. For the example shown, table **81** indicates a SIM no. **82** (**1**) that has PIN **70** (5821) and ISDN **72** (ww-xxx-yyy-zzzz) and is associated with seat back handset no. **84** (22-B) coupled to transceiver no. **83** (**2**).

As mentioned before, the association between SIM no. **82** and seat back handset no. **84** can take different forms. In one embodiment access ports **50** (FIG. **2**) are located at each seat back location, so that the above association is made when original SIM **56** is inserted into access port **50** (FIG. **2**) located at the subscriber's seat back. In another embodiment, a group of access ports **50** are located together at a bulkhead in aircraft **20** and arranged or labeled so that each access port **50** corresponds to its own seat back handset no. **84**. In yet another embodiment, several access ports **50** (FIG. **2**) are available to subscribers as they enter aircraft **20** and the subscriber makes the association by inserting original SIM **56** into access port **50** and entering an assigned seat number through I/O device **52** (FIG. **2**). In another alternative embodiment, a bulkhead SIM reader would be linked with a seatback via swipes of a credit card at both places. This would be an alternative to entering a seat number at the bulkhead or having a SIM carrier for each seat.

FIG. **5** shows an exemplary availability list of transceivers **85** maintained by controller **42** and stored in operational memory **58** (FIG. **2**). An integer number M of subscribers, each having their own original SIM **56** that corresponds to a SIM no. **82** is shown in FIG. **4**. The number M can be larger than the integer number N of transceivers **36** provided by exchange **32**. Hence, there can be more subscribers M than transceivers N (FIGS. **4** and **5**). Subscriber exchange **32** tracks availability of transceivers **36** and maintains availability list of transceivers **85**. For the example shown in FIG. **5**, one of transceiver nos. **83** (i.e. **2**) is unavailable as it is being used by the subscriber having SIM no. **82** (**1**) and seat back handset **84** no. (22-B), as shown in FIG. **4**. In the example presented in FIG. **5**, another of transceiver nos. **83** (i.e. **4**) is also unavailable and is shown as being reserved, possibly for placing emergency calls.

FIG. **6** shows a flowchart of a first part of an exemplary SIM coupling process **87** that is used by subscriber exchange **32** in a preferred embodiment of the present invention. FIG. **7** shows a second part of process **87**. FIG. **6** shows SIM coupling process **87** as beginning at an arbitrary starting point **89** in an idle loop **91**. Idle loop **91** is a processing loop that includes query steps that direct processing control flow based on responses to query steps.

Within idle loop **91**, query step **86** checks for the presence of a newly inserted original SIM **56** in one of access ports **50**. When original SIM **56** is inserted into access port **50** (FIG. **2**), query step **86** proceeds to step **88**. Otherwise, process flow returns to idle loop **91**, as indicated at a connector "A" which links idle loop **91** to the flowchart presented in FIG. **7**.

During step **88**, controller **42** prompts the subscriber to enter a PIN through I/O device **52** (FIG. **2**). This prompt or request can be an audible beep followed by a display of words requesting that the user enter his or her PIN. Upon entry of the PIN by the subscriber, it is stored in memory **58**. Following step **88** controller **42** (FIG. **2**) extracts and saves PIN **70** (FIG. **3**) from original SIM **56** (FIG. **2**) in step **90**. Upon the extraction of PIN **70**, it is stored in table **81** (FIG. **4**). Next, query step **92** compares, the subscriber-entered PIN to the extracted PIN **70** for a match. If no match is found, original SIM **56** is relinquished to the subscriber in step **94**, and control flow returns to idle loop **91**.

The relinquishing act may include unlocking lock mechanism **54** and/or prompting the user to retrieve original SIM **56** by issuing an audible or visual alert signal through I/O device **52**. By relinquishing original SIM **56**, the user is then allowed to retrieve original SIM **56** from access port **50**.

If a match is found in step **92**, controller **42** grants access to subscriber exchange **32** and uses a list of transceivers **85** (FIG. **5**) to select an available transceiver **36** in step **96**. An available transceiver is one that is marked as being available in table **85** (FIG. **5**). Following step **96**, the available transceiver **36** is coupled to original SIM **56**, and that transceiver **36** is marked as being unavailable in the availability list of transceivers **85** (FIG. **5**) in step **98**. By coupling transceiver **36** with original SIM **56**, exchange **32** establishes a one-to-one relation between original SIM **56** and transceiver **36**, at least temporarily. Transceiver **36** is coupled to original SIM **56** by controlling data switch **40** to connect selected access port **50** with selected transceiver **36**.

Following step **98**, exchange **32** and communication network **26** perform a conventional authentication verification process on original SIM **56** (not shown). The results of that authentication process are evaluated in query step **100**.

If communication network **26** does not verify the authentication of original SIM **56** during the authentication process, program control proceeds to step **101**. During step **101**, original SIM **56** is relinquished to the user in the manner described above in connection with step **94**. Following step **101**, step **102** decouples transceiver **36**, breaking the one-to-one relationship between transceiver **36** and original SIM **56**. Step **102** decouples transceiver **36** by sending disconnecting commands to data switch **40** and by erasing the transceiver no. **83** associated with the original SIM no. **82** in table **81** (FIG. **4**). In addition, step **102** marks that transceiver **36** as now being available on list **85** (FIG. **5**) and program flow then returns to idle loop **91**.

If authentication is verified in step **100**, step **104** extracts and saves ISDN **72** in table **81** (FIG. **4**). ISDN **72** is extracted from original SIM **56**. In addition, step **104** may update original SIM **56** (not shown). In updating original SIM **56**, the current geolocation **74** (FIG. **3**) may be stored to original SIM **56**. A current geolocation can be determined as a part of the registration process. Geolocation information can be used to determine when to perform the registration process

so that the system is kept informed of the original SIM's location and the system can then accurately direct incoming ring signals to the original SIM. In addition, in updating original SIM **56**, equipment identity **76** (FIG. 3) is desirably stored on original SIM **56** to identify transceivers **36** and exchange **32**. If radio equipment used in communication network **26**, including exchange **32**, finds an original SIM **56** having an equipment identity **76** incompatible with its own equipment identity, then this event can provide a registration process so that communication network **26** is kept informed of the equipment type with which an original SIM is being used, and the system can then accurately direct appropriate incoming ring signals to the original SIM.

In one embodiment, controller **42** forms and/or activates a substitute or temporary SIM in step **106**. A temporary SIM may be formed or activated merely by storing ISDN **72** in table **81** so that it is associated with a specified seat back handset no. **84**.

Alternatively, a fully functional actual or simulated temporary SIM which is in the possession of exchange **32** may be activated and an index number of such a temporary SIM stored in table **81** in association with a specified seat back handset no. **84**. In this embodiment, the temporary SIM has its own ISDN **72**, security key **80**, and processing capability to perform the authentication process. That processing capability may be, but is not required to be, provided by processor **62** of controller **42** (FIG. 2). In either embodiment, an association is established indicating that the temporary SIM corresponds to original SIM **56**. When M original SIMs **56** are being serviced by exchange **32**, M temporary SIMs are activated to correspond to the M original SIMs.

Step **106** also indicates that original SIM **56** may be locked into access port **50** in the manner discussed above. Original SIMs **56** are desirably locked in access ports **50** in an embodiment of the present invention which does not use temporary SIMs. This embodiment is described in more detail below. Original SIMs **56** may, but need not, be locked in access ports **50** when temporary SIMs are used because they will soon be relinquished.

Following step **106**, controller **42** activates call forwarding when the temporary SIM has its own ISDN **72** by instructing network **26** to forward calls directed to original SIM **56** on to the temporary SIM in step **108**. In addition, step **108** may instruct network **26** to transfer billings for the temporary SIM over to the subscriber's original SIM **56**. After completing step **108**, the selected transceiver **36** is decoupled from original SIM **56** in step **110**, and the selected transceiver **36** is marked available on list **85** of transceivers (FIG. **5**) in step **112**. Steps **110** and **112** operate in a manner similar to step **102**, discussed above.

After step **112**, step **114** causes controller **42** to associate seat back handset no. **84** (FIG. **4**) with the temporary SIM that has been activated to correspond with the original SIM **56**. Step **114** is performed by making an appropriate entry in table **81**. In addition, ISDN **72** stored in table **81** in association with the seat back handset no. **84** and SIM no. **82** may be set to the ISDN of the temporary SIM rather than the ISDN from the original SIM **56**. Following step **114**, original SIM **56** is relinquished from access port **50** in step **116**, and program flow returns to idle loop **91**.

The subscriber may maintain possession of his or her original SIM **56**. Communication services, including outgoing and incoming calls will be provided using the temporary SIM in a manner discussed below. Since the subscriber can maintain possession of his or her original SIM **56**, the subscriber is unlikely to accidentally leave original SIM **56** behind when departing airplane **20** and system security remains high. Authentication security has been extended from original SIM **56** to the temporary SIM which will be used for that subscriber throughout the duration of the flight.

FIG. 7 shows a second part of SIM coupling process **87**. Idle loop **91** continues in FIG. 7 as indicated through connectors "A" and "B". Within idle loop **91**, controller **42** monitors or screens incoming ring signals for conveyed ISDNs matching ISDNs **72** from call association table **81** (FIG. **4**) in query step **118**. The ring signals are received at one or more of transceivers **36** over a control or broadcast channel. The one or more transceivers **36** which monitor the control or broadcast channel decode the ring signals and then pass ring signal or page messages along to controller **42**.

When step **118** identifies a match, the subscriber is alerted to an incoming call through I/O device **46** of handset **44** in step **120**. A particular handset **44** is identified through the seat back handset no. **84** associated in table **81** (FIG. **4**) with ISDN **72** conveyed by the just-detected ring signal. The subscriber may be alerted by an audible or visual signal emitted by I/O device **46**. After step **120**, transceiver **36** is selected from list **85** (FIG. **5**) in step **122**. Step **122** operates in a manner similar to that discussed above in connection with step **96** (FIG. **6**).

Following step **122**, controller **42** couples the selected transceiver **36** with the corresponding SIM in step **124**. The corresponding SIM to which the selected transceiver **36** is coupled can be the temporary SIM whose index number is associated with the just-detected ISDN **72** in table **81** (FIG. **4**). In another embodiment discussed below, the corresponding SIM can be an original SIM **56** whose index number is associated with the just-detected ISDN **72** in table **81**. For the temporary SIM, this coupling simulates the coupling performed in step **98**, where transceiver **36** was physically coupled to original SIM **56**. Otherwise, this coupling is substantially similar to that discussed above in connection with step **98**.

Following step **124**, seat back handset **44** identified by call association table **81** is coupled to the selected transceiver **36** in step **126**. Step **126** couples the selected handset **44** and transceiver **36** together through appropriate control of voice switch **38** (FIG. **2**). After step **126**, step **128** is performed while the incoming call to the subscriber is underway. When the call is completed, step **132** decouples the selected transceiver **36** from the SIM and seat back handset **44**. When step **132** decouples transceiver **36**, it is marked as available on list **85** of transceivers (FIG. **5**), and control flow returns to idle loop **91**.

Returning to step **118**, when the ISDNs of incoming ring signals do not match any of ISDNs **72** in table **81** (FIG. **4**), program flow continues through idle loop **91** to query step **136** to monitor for outgoing calls. A request for making an outgoing call is detected by controller **42** when a user appropriately manipulates I/O device **46** (FIG. **2**). If controller **42** does not detect a request for an outgoing call, program flow continues in idle loop **91**.

However, if a request for an outgoing call is detected, controller **42** verifies the subscriber's PIN in step **137**. The subscriber's PIN may be verified in a manner similar to that discussed above in connection with steps **88** and **92** (FIG. **6**). The user is prompted to enter the PIN, and the user-entered PIN is checked against PIN **70** listed in table **81** in association with the seat back from where the request for an outgoing call originates. If the subscriber's PIN is not verified, then the request for making an outgoing call is

denied, and program flow returns to idle loop **91** (not shown). Thus, step **137** extends authentication security by preventing persons who are unlikely to know the correct PIN from using another's services while on aircraft **20** even when the original SIM **56** has been relinquished and communication and authentication are being provided using a more public temporary SIM.

When the subscriber's PIN is verified, controller **42** selects a transceiver **36** from list **85** (FIG. 5) in step **138**. Transceiver **36** is selected in substantially the same manner as discussed above in connection with steps **96** and **122**. Following step **138**, step **140** couples the SIM whose index number **82** (FIG. 4) is associated with the seat back requesting the outgoing call to the selected transceiver **36**. This coupling occurs through data switch **40** or by simulation of a SIM (i.e. a temporary SIM) in controller **42**. Following step **140**, step **142** couples the selected transceiver **36** to the appropriate seat back handset **44** as determined from call association table **81** (FIG. 4). This coupling occurs through voice switch **38**. Next, step **144** is performed while the outgoing call is underway. When the call is completed, step **146** decouples the selected transceiver **36** from the SIM and seat back handset **44**. When step **146** decouples transceiver **36**, it is marked as available on list **85** of transceivers (FIG. 5), and control flow returns to idle loop **91**.

Idle loop **91** also includes query step **148** that monitors aircraft **20** for a landing condition as determined through the input of flight status indicator **48** (FIG. 2). When no landing condition is detected, program flow continues through idle loop **91**. When a landing condition is eventually detected, all temporary SIMs are deactivated or erased in step **150**. Following step **150**, subscriber exchange **32** instructs communication network **26** to cease call forwarding in step **152** and to transfer billing activity for the temporary SIM away from the previously corresponding original SIM **56**. After step **152**, program flow returns to idle loop **91**. The deactivating of temporary SIMs and call forwarding and the transferring of billing activity breaks the previously established associations or correspondence between original SIMs **56** and temporary SIMs. Thus, the extension of authentication security provisions from original SIMs to temporary SIMs continues only for a limited time and no significant weakening of system security results.

Those skilled in the art will appreciate that process **87**, discussed above in connection with FIGS. **6** and **7**, may be performed concurrently for any number of original SIMs **56**, and particularly for a number M of original SIMs **56** which is greater than the number N of transceivers **36** provided by exchange **32**. Thus, a one-to-one correspondence between SIMs and transceivers **36** is not continuously required, and a pool of transceivers **36** may be efficiently used to securely provide public communication services for a greater number of subscribers.

As discussed above, in one alternate embodiment of the present invention a temporary SIM may consist merely of ISDN **72** extracted from an original SIM **56**. In this embodiment, the temporary SIM allows exchange **32** to provide a paging communication service for the subscriber even though an original SIM **56** is not present. Above-described step **108** is omitted and no call forwarding is performed. However, this ISDN is associated with a seat back handset no. **84** in table **81** (FIG. 4), and the subscriber's original SIM **56** is nevertheless relinquished in step **116**. Thus, the subscriber may keep original SIM **56** in his or her possession at all times so that system security remains intact.

For this embodiment, when an incoming call's ISDN matches an ISDN **72** from table **81** (FIG. 4), the subscriber is alerted to the incoming call as in step **120**. However, after alerting the subscriber, controller **42** waits for up to a predetermined duration after step **120** to allow the subscriber to reinsert original SIM **56** into access port **50** (FIG. 2). Accordingly, exchange **32** reaccesses the subscriber's original SIM **56** while waiting after step **120**. The call setup process will then use the subscriber's original SIM **56** accessed through access port **50** to provide the additional communication services of call setup and voice communication as process **87** continues with step **122**.

In this embodiment, when a subscriber desires to place a call the subscriber reinserts original SIM **56** into access port **50** (FIG. 2) before call setup. Step **137** may be omitted, but call setup continues with step **138** and uses the subscriber's original SIM **56**. After steps **132** or **146**, a relinquishing step similar to steps **94** and **116** (FIG. 6) can be performed because the subscriber has reinserted original SIM **56** into access port **50**. Moreover, for this embodiment, when a landing condition is detected, step **150** erases only PIN **70** and ISDN **72** from table **81** to deactivate the temporary SIM. Since no call forwarding was performed, step **152** may be omitted.

In another embodiment of the present invention, no substitute or temporary SIM is activated. Accordingly, above-described step **106** locks original SIMs **56** into access ports **50** as discussed above. Steps **108** and **116** (FIG. 6) are omitted from SIM coupling process **87**. Since original SIMs **56** are locked, the subscribers may have confidence that their original SIMs **56** will not be stolen and system security remains high. Since they remain at access ports **50**, they are available for use in connection with registration, incoming calls, and outgoing calls. In steps **124**, **132**, **140**, and **146**, the SIMs being coupled and decoupled are the original SIMs **56** which are locked in place at access ports **50**. Steps **148**, **150**, and **152** may be omitted. Associations between SIMs and seat backs may be broken when the subscribers regain possession of their original SIMs **56**.

FIG. **8** shows a flowchart of an exemplary SIM relinquishing process which is included in idle loop **91** and performed for the embodiment of the present invention where original SIMs **56** remain locked in place at access ports **50**. Accordingly, idle loop **91** causes program flow to proceed to query step **154**. Step **154** monitors for a request to relinquish original SIM **56** from access port **50**. That request may come from the subscriber or from another source, such as aircraft personnel. If no such request is detected, program flow returns to idle loop **91**.

When a return original SIM **56** request is detected, step **156** issues a prompt for the subscriber's PIN through I/O device **46** or **52** (FIG. 2). After the subscriber enters his or her PIN, query step **158** checks the entered PIN to see if it matches a PIN **70** from table **81** (FIG. 4). When a match is detected, controller **42** unlocks locking mechanism **54** for the corresponding original SIM **56** and relinquishes original SIM **56** in step **160**, then program flow returns to idle loop **91**. If the subscriber enters a PIN that does not match PIN **70**, original SIM **56** remains locked in access port **50** and program flow continues through idle loop **91**. Aircraft personnel may have access to an overriding code that could be used to help passengers retrieve their original SIMs should they forget their PINs.

In summary, a multi-channel subscriber exchange **32** provides authentication and communication services to subscribers through transceivers **36**. Original SIM **56** is used for authentication purposes without significantly weakening conventional security. Authentication and communication

services are provided without imposing the inefficiency of a one-to-one correspondence between SIMs and transceivers.

Although the preferred embodiments of the invention have been illustrated and described in detail, it will be readily apparent to those skilled in the art that various modifications may be made therein without departing from the spirit of the invention or from the scope of the appended claims.

What is claimed is:

1. A method for operating an aircraft subscriber exchange that couples to a network providing communication and authentication services, the method comprising the steps of:

(a) receiving an original subscriber identity module (SIM) with an access port of the aircraft subscriber exchange;

(b) accessing subscriber-specific data from said original SIM received with said access port;

(c) performing an authentication process with the network using said original SIM;

(d) extracting said subscriber-specific data from said original SIM:

(e) establishing an association between said original SIM and a temporary SIM, said association extending said subscriber-specific data of said original SIM to said temporary SIM;

(f) relinquishing said original SIM from said access port;

(g) providing communication services for said original SIM using said temporary SIM; and

(h) deactivating said temporary SIM based upon detection of a predefined event related to control of an aircraft.

2. The method for operating an aircraft subscriber exchange as recited in claim **1**, wherein

said predefined event is a landing of said aircraft.

3. The method for operating an aircraft subscriber exchange as recited in claim **2**, wherein

step (h) includes instructing the network to cease forwarding calls directed to the original SIM on to the temporary SIM.

4. The method for operating an aircraft subscriber exchange as recited in claim **1**, wherein:

the network provides communication services for subscribers over channels;

steps (a)–(g) are repeated for a quantity M of said temporary SIMs and a quantity M of said original SIMs, where M is an integer number; and

said communication services are provided through a quantity N of transceivers, where N is an integer number less than M.

5. The method for operating an aircraft subscriber exchange as recited in claim **4**, wherein step (g) includes the steps of:

(i) selecting one of said temporary SIMs and one of said transceivers; ad

(j) coupling said selected one of said temporary SIMs and said one of said transceivers.

6. The method for operating an aircraft subscriber exchange as recited in claim **1**, wherein

said subscriber-specific data from said original SIM includes a personal identification number (PIN); and

the method further comprises the step of prompting for entry of said PIN after step (f) and prior to step (g).

7. The method for operating an aircraft subscriber exchange as recited in claim **1**, wherein said subscriber-specific data from said original SIM includes an international subscriber directory number (ISDN) and step (d) includes extracting said ISDN from said original SIM, and the method further comprises the steps of:

(i) monitoring incoming ring signals which convey ISDNs; and

(j) screening said ISDNs conveyed with said incoming ring signals for a match with an ISDN of said temporary SIM.

8. The method for operating an aircraft subscriber exchange as recited in claim **7**, wherein step (g) includes alerting a subscriber when step (j) detects said match with said temporary SIM, and the method further comprises the steps of:

(k) waiting a predetermined duration following the alerting step to allow the subscriber to provide said original SIM;

(l) reaccessing said subscriber-specific data from said original SIM during step (k); and

(m) providing additional communication services in response to step (l).

9. The method for operating an aircraft subscriber exchange as recited in claim **1**, wherein:

the exchange includes a plurality of handsets through which said communication services can be provided; and

step (e) includes associating one of said plurality of handsets with said temporary SIM.

10. A method for operating an aircraft subscriber exchange that couples to a network providing communication and authentication services for subscribers over channels, the method comprising the steps of:

(a) receiving a quantity M of original subscriber identity modules (SIMs) with a plurality of access ports of the aircraft subscriber exchange, where M is an integer;

(b) accessing subscriber-specific data from said quantity M of original subscriber identity modules SIMs;

(c) performing an authentication process with the network for each of said quantity M of original SIMs;

(d) extracting said subscriber-specific data from said quantity M of original SIMs;

(e) establishing an association between each of said quantity M of original SIMs and a quantity M of temporary SIMs, said association extending said subscriber-specific data of each of said quantity M of original SIMS on to one of said quantity M of temporary SIMs;

(f) relinquishing said quantity M of original SIMs from said plurality of access ports;

(g) controlling no more than a quantity N of transceivers where N is an integer number less than M;

(h) selecting, after step (f), one of said quantity M of temporary SIMs and one of said quantity N of transceivers;

(i) coupling the selected temporary SIM and the selected transceiver together;

(j) providing communication services for one of said quantity M of original SIMs using said one of said quantity M of temporary SIMs and one of said quantity N of transceivers selected in step (h); and

(k) deactivating said quantity M of temporary SIMs based upon detection of a predefined event related to the control of an aircraft.

11. The method for operating an aircraft subscriber exchange as recited in claim **10**, wherein:

said quantity M of original SIMs store personal identification numbers (PINs);

step (d) includes extracting said PINs from said quantity M of original SIMs; and

the method further comprises the step of prompting for entry of said PINs.

12. The method for operating an aircraft subscriber exchange as recited in claim **10**, wherein:

the aircraft subscriber exchange includes a plurality of handsets through which said communication services can be provided; and

step (h) comprises the step of associating a selected one of said plurality of handsets with said selected one of said quantity M of temporary SIMs; and

step (i) couples said selected one of said plurality of handsets to the selected transceiver.

13. A multi-channel subscriber exchange of an aircraft coupled to a network that provides communication and authentication services for subscribers over channels, the multi-channel subscriber exchange of the aircraft comprising:

a plurality of transceivers;

an access port;

a temporary subscriber identity module (SIM);

a controller connected to said plurality of transceivers, said access port, and said temporary SIM, said controller being configured to:

access subscriber-specific data from an original SIM received by said access port and perform an authentication process with the network using said original SIM;

extract said subscriber-specific data from said original SIM received by said access port;

establish an association between said original SIM and said temporary SIM, said association extending said subscriber-specific data of said original SIM to said temporary SIM

relinquish said original SIM from said access port;

couple said temporary SIM to one of said plurality of transceivers to provide the communication services using said temporary SIM; and

deactivate said temporary SIM based upon detection of a predefined event related to the control of the aircraft.

14. The multi-channel subscriber exchange of an aircraft as recited in claim **13**, wherein:

said predefined event is an aircraft landing.

15. The multi-channel subscriber exchange of an aircraft as recited in claim **13**, wherein:

said original SIM is one of a quantity M of original SIMs, where M is an integer number;

said temporary SIM is one of a quantity M of temporary SIMs; and

said plurality of transceivers are of a quantity N, where N is an integer number less than M.

16. The multi-channel subscriber exchange of an aircraft as recited in claim **13**, wherein the exchange includes a plurality of handsets and said controller is configured to associate one of said plurality of handsets with said temporary SIM.

17. The method for operating an aircraft subscriber exchange as recited in claim **1**, further comprising the step of instructing the network to forward communication services directed to said original SIM on to said temporary SIM utilizing said association extending said subscriber-specific data of said original SIM to said temporary SIM.

18. The method for operating an aircraft subscriber exchange as recited in claim **10**, farther comprising the step of instructing the network to forward communication services directed to said quantity M of original SIMs on to said quantity M of temporary SIMs utilizing said association extending said subscriber-specific data of each of said quantity M of original SIMs to said quantity M or temporary SIMs.

19. The multi-channel subscriber exchange of an aircraft as recited in claim **13**, wherein the controller is further configured to instruct the network to forward communication services directed to said original SIM on to said temporary SIM utilizing said association extending said subscriber-specific data of said original SIM to said temporary SIM.

* * * * *

UNITED STATES PATENT AND TRADEMARK OFFICE

CERTIFICATE OF CORRECTION

PATENT NO. : 6,002,929

DATED : December 14, 1999

INVENTOR(S) : James William Bishop, Jr. et al.

It is certified that error appears in the above-identified patent and that said Letters Patent is hereby corrected as shown below:

On the front page, after "[73] Assignee:" replace "Mototrola, Inc." with --Motorola, Inc.--.

Column 11, line 54, after "transceivers;", replace "ad" with --and--.

Signed and Sealed this

Tenth Day of April, 2001

Attest:

Nicholas P. Godici

NICHOLAS P. GODICI

Attesting Officer

Acting Director of the United States Patent and Trademark Office